Enclosure (3)
Groundfish PDT report dated July 27, 2012

Effect of CV and Bias on Sector Catch Estimates

The goal of monitoring discards in sectors is to make sure there is an accurate accounting of sector catches. The level of needed observer coverage depends on the desired degree of catch accuracy.

The sector and stock-specific CV of discard estimates can be used to characterize the likelihood that the actual catches exceed a sector's ACE. The following discussion uses these assumptions:

- Landings are known without error. This assumption could be relaxed if information is available on the uncertainty surrounding landings.
- Discard estimates are unbiased. This assumption will be modified in a subsequent discussion.
- Discard estimates are normally distributed random variables.

CV is normally defined as the standard deviation (SD) of an estimate divided by the mean of the estimate. In the SBRM framework, however, CV is defined as the standard error of the estimate divided by the estimate. CV is a dimension-less value. If the CV and point estimate of the discards are known, then the SE can be determined as:

CV= SE of the estimate/ estimate
CV * estimate = SE

This relationship allows creation of a confidence interval around any discard estimate. The interval that is plus/minus 1.96 * SE of the estimate will cover 95 pct of the distribution. There is a 97.5 pct probability that the discard estimate will be equal to or less than the mean plus 1.96 times the SE. With discards at a given proportion of the catch, the SE can be used to determine the upper bound of the confidence interval, shown in Table 1.

Any discard estimate can be expressed as a proportion of a sector's nominal catch (landings plus the discard estimate); landings can also be expressed as a proportion of the nominal catch. If, as assumed, landings are known without error and the discard estimate is unbiased, then the CV of the discard estimate can be used to calculate a catch that has a 97.5 pct probability of being less than or equal to the actual catch:

$$Catch_{98\ pct} = Landings + Discards + (Discards * 1.96 * CV)$$

The result of this formula will always be equal to or greater than 1, because both landings and discards are being expressed as a proportion of catch. The catch increases as discards increase and CV increases. Results are shown in Table 2.

At what point does the $Catch_{UpperCI}$ exceed the sector's ACE? This would occur when the actual catch, as a proportion of the ACE, exceeds 1. This can be determined for each cell

in Table 2 by dividing 1 by the $Catch_{UpperCI}$. This gives the nominal catch, as a proportion of ACE, above which the sector ACE may be exceeded for a given discard rate and CV. This ACE is referred to as ACE_{max}.The results are shown in Table 3.

Table 4 gives the results if the criterion is that ACE not be exceeded with a probability of about 84 pct, based on one standard deviation of the SE of the discard estimate.

Discussion – Unbiased Estimates of Discards

From the standpoint of monitoring sector discards to make certain that catches remain under the ACE allocated, both the CV of the discard estimate and the proportion of the catch that is discarded are important. Sector nominal catches can be a higher percentage of ACE without risk of exceeding the ACE if the CV is reduced and/or the discards as a percentage of the sector catch area reduced. This gives a potential way to evaluate the costs of improving (decreasing) the CV at a given level of discards. For example, if discards are about 10 percent of the catch, then improving the CV by 5 percent increases the ACE_{max} (as a proportion of ACE) by about 1 percent. The increased value of this catch could be compared to the cost of improving the CV to determine if it is worthwhile.

The previous analysis assumes that discards are unbiased.

At a given CV, each 5 percent reduction in discards increases the ACE_{max} by more than occurs with a 5 percent improvement in CV.

In FY 2010, the discards of most stocks in individual sectors were in the range of 0 to 15 per cent, with a few exceptions (most notably, stocks where discards were required).

Biased Discard Estimates

The previous analysis assumes that discards are unbiased. The implications of biased discard estimates can be explored by assuming that the true discard estimate is a multiple of the nominal discard estimate. For example, if nominal discards are estimated to be 0.1 of the catch, then the actual discards were assumed to be twice this amount - a doubling of the estimate. The implications of this on actual catch can be explored, including the effects that a bias assumption has on the amount of ACE_{max} . This approach assumes the CV remains accurate for the revised discard estimate.

Results are shown for a bias multiplier of 2 in Table 5 through Table 7. The presence of a bias results in a reduction in the ACE_{max}. Figure 1 compares the results of two bias multipliers to the no bias result when the nominal discards are 10 percent of the nominal catch. Figure 2 compares the maximum nominal catch for different nominal discard rates with a bias multiplier of 2.

Discussion – Biased Discard Estimates

If discard estimates are biased then nominal catches need to be lower to have a high probability that the ACE is not exceeded. The CV of the discard estimate also becomes more important, as can be seen from Figure 2. If discard estimates are not biased, changing the CV of the discard estimate from 0.55 to 0.3 only increases the ACE_{max} by 0.41 percent. If the discards are under-estimated by a factor of 2, then a similar change in CV increases the ACE_{max} by 0.061 percent . Put another way, if discard estimates are not biased, then at a discard rate of 10 pct of the catch, reducing the CV by 5 percent increases ACE_{max} by about 0.009. If discards are biased and nominal discards are the same, then improving the CV by 5 percent increases ACE_{max} by about 1.4 percent (with a range of 1.1 percent to1.6 percent for CVs of 0.55 to 0).

Using the FY 2010 sector sub-ACLs and average prices per species, the value of increasing the ACE_{max} by 0.009 can be calculated as $2.2 million (if GB haddock and redfish are included) or $840,000 if these two stocks are excluded (because catches are far lower than the quotas). With an estimate of the increased costs of observer coverage to achieve this change, a determination can be made whether the improved CV is cost effective. This estimate is likely an over-estimate for FY 2010, because in most cases the catches, as a percent of the sub-ACL, were lower than the ACE_{max} values for discards at 10 percent of catch.

Bias – An Exploration

In simple terms, total discards of a stock (Dt) by a sector are estimated as a combination of the observed discards on an observed trip (Do)and the unobserved discards on unobserved trips (Du). The discards for unobserved trips are estimated based on the ratio of discards of the stock to the total kept catch on the observed trips (do/ko); this ratio is multiplied by the total kept catch on the unobserved trips (ku)[1].

$$Dt = Do + Du$$

$$Dt = Do + (do/ko)*ku$$

If it is suspected that there is a bias in the discard estimate, then the true discards are some multiple of the estimated discards.

$$\text{True Discards} = X * Dt = X (Do + (do*ku/ko))$$

[1] This discussion simplifies the actual discard calculation for clarity.

Because Do is known, and ku is known, if there is a bias in a discard estimate for a stock it is because the discard ratio on unobserved trips differs from the do/ko used to estimate discards. It should be emphasized that this represents a change in rate, not just an increase of decrease in the amount discarded. In other words, if bias is present:

$$du/ku = Y*do/ko$$

where Y is a bias multiplier

$$x*Dt=Do+ Y*do/ko*ku$$

Since Do, do/ko, and ku do not change, the factor Y can be determined if the bias factor is either known or assumed:

$$(x*Dt-Do)/(do*ku/ko) = Y$$

This relationship provides a way to determine, for a given suspected bias in the discard estimate, how much the discard ratio on unobserved trips differs from the discard ratio on observed trips. The difference between the ratios increases as the suspected bias increases, and also increases as the proportion of observed kept catch increases. The relative difference is not dependent on the observed discard rate; it is dependent on the observer coverage level, expressed as the ratio of observed kept catch to unobserved kept catch.

If a positive bias is suspected (true discards exceed estimated discards), the discard ratio on unobserved trips must be higher than the discard ratio on the observed trips (Figure 3). At a minimum it must be the same as the suspected bias, and at low coverage levels (up to 25 percent) it differs from this amount by only a few percent. As coverage increases, the relative discard rate difference becomes larger than the suspected bias multiplier. At coverage levels of 50 percent and above, the discard rate must be dramatically different than the suspected bias. For example, at 50 percent coverage and with a suspected bias multiplier of three, the discard rate on unobserved trips must be five times the discard rate on observed trips.

For fishing behavior to be sufficiently different on unobserved trips to lead to a bias in the discard estimate, there must be a benefit – real or perceived – to the change in behavior. One possibility might be high-grading - discarding lower value catch in order to retain more valuable catch at a given weight. With multiple stocks, another rationale would be if the increased discarding on unobserved trips allows increased revenues from other stocks. This would seem more likely if there are stocks with low quotas that are limiting fishing activity by sector vessels.

Table 1 – Discards plus 1.96* SE of discards as a percent of catch

	CV											
Nominal Discards as Pct of Catch	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.05	0.050	0.055	0.060	0.065	0.070	0.075	0.079	0.084	0.089	0.094	0.099	0.104
0.1	0.100	0.110	0.120	0.129	0.139	0.149	0.159	0.169	0.178	0.188	0.198	0.208
0.15	0.150	0.165	0.179	0.194	0.209	0.224	0.238	0.253	0.268	0.282	0.297	0.312
0.2	0.200	0.220	0.239	0.259	0.278	0.298	0.318	0.337	0.357	0.376	0.396	0.416
0.25	0.250	0.275	0.299	0.324	0.348	0.373	0.397	0.422	0.446	0.471	0.495	0.520
0.3	0.300	0.329	0.359	0.388	0.418	0.447	0.476	0.506	0.535	0.565	0.594	0.623
0.35	0.350	0.384	0.419	0.453	0.487	0.522	0.556	0.590	0.624	0.659	0.693	0.727
0.4	0.400	0.439	0.478	0.518	0.557	0.596	0.635	0.674	0.714	0.753	0.792	0.831
0.45	0.450	0.494	0.538	0.582	0.626	0.671	0.715	0.759	0.803	0.847	0.891	0.935
0.5	0.500	0.549	0.598	0.647	0.696	0.745	0.794	0.843	0.892	0.941	0.990	1.039
0.55	0.550	0.604	0.658	0.712	0.766	0.820	0.873	0.927	0.981	1.035	1.089	1.143
0.6	0.600	0.659	0.718	0.776	0.835	0.894	0.953	1.012	1.070	1.129	1.188	1.247
0.65	0.650	0.714	0.777	0.841	0.905	0.969	1.032	1.096	1.160	1.223	1.287	1.351
0.7	0.700	0.769	0.837	0.906	0.974	1.043	1.112	1.180	1.249	1.317	1.386	1.455
0.75	0.750	0.824	0.897	0.971	1.044	1.118	1.191	1.265	1.338	1.412	1.485	1.559
0.8	0.800	0.878	0.957	1.035	1.114	1.192	1.270	1.349	1.427	1.506	1.584	1.662
0.85	0.850	0.933	1.017	1.100	1.183	1.267	1.350	1.433	1.516	1.600	1.683	1.766
0.9	0.900	0.988	1.076	1.165	1.253	1.341	1.429	1.517	1.606	1.694	1.782	1.870
0.95	0.950	1.043	1.136	1.229	1.322	1.416	1.509	1.602	1.695	1.788	1.881	1.974
1	1.000	1.098	1.196	1.294	1.392	1.490	1.588	1.686	1.784	1.882	1.980	2.078

Table 2 – Landings plus discards plus 1.96 times SE of discards as a percent of catch

	CV											
Landings as Pct of Catch	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.95	1.000	1.005	1.010	1.015	1.020	1.025	1.029	1.034	1.039	1.044	1.049	1.054
0.9	1.000	1.010	1.020	1.029	1.039	1.049	1.059	1.069	1.078	1.088	1.098	1.108
0.85	1.000	1.015	1.029	1.044	1.059	1.074	1.088	1.103	1.118	1.132	1.147	1.162
0.8	1.000	1.020	1.039	1.059	1.078	1.098	1.118	1.137	1.157	1.176	1.196	1.216
0.75	1.000	1.025	1.049	1.074	1.098	1.123	1.147	1.172	1.196	1.221	1.245	1.270
0.7	1.000	1.029	1.059	1.088	1.118	1.147	1.176	1.206	1.235	1.265	1.294	1.323
0.65	1.000	1.034	1.069	1.103	1.137	1.172	1.206	1.240	1.274	1.309	1.343	1.377
0.6	1.000	1.039	1.078	1.118	1.157	1.196	1.235	1.274	1.314	1.353	1.392	1.431
0.55	1.000	1.044	1.088	1.132	1.176	1.221	1.265	1.309	1.353	1.397	1.441	1.485
0.5	1.000	1.049	1.098	1.147	1.196	1.245	1.294	1.343	1.392	1.441	1.490	1.539
0.45	1.000	1.054	1.108	1.162	1.216	1.270	1.323	1.377	1.431	1.485	1.539	1.593
0.4	1.000	1.059	1.118	1.176	1.235	1.294	1.353	1.412	1.470	1.529	1.588	1.647
0.35	1.000	1.064	1.127	1.191	1.255	1.319	1.382	1.446	1.510	1.573	1.637	1.701
0.3	1.000	1.069	1.137	1.206	1.274	1.343	1.412	1.480	1.549	1.617	1.686	1.755
0.25	1.000	1.074	1.147	1.221	1.294	1.368	1.441	1.515	1.588	1.662	1.735	1.809
0.2	1.000	1.078	1.157	1.235	1.314	1.392	1.470	1.549	1.627	1.706	1.784	1.862
0.15	1.000	1.083	1.167	1.250	1.333	1.417	1.500	1.583	1.666	1.750	1.833	1.916
0.1	1.000	1.088	1.176	1.265	1.353	1.441	1.529	1.617	1.706	1.794	1.882	1.970
0.05	1.000	1.093	1.186	1.279	1.372	1.466	1.559	1.652	1.745	1.838	1.931	2.024
0	1.000	1.098	1.196	1.294	1.392	1.490	1.588	1.686	1.784	1.882	1.980	2.078

Table 3 - Maximum Nominal Catch Where Actual Catch < ACE With a Probability of 97.5 pct

	CV											
Discards as Pct of Catch	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
0	1	1	1	1	1	1	1	1	1	1	1	1
0.05	1	0.995	0.990	0.986	0.981	0.976	0.971	0.967	0.962	0.958	0.953	0.949
0.1	1	0.990	0.981	0.971	0.962	0.953	0.944	0.936	0.927	0.919	0.911	0.903
0.15	1	0.986	0.971	0.958	0.944	0.932	0.919	0.907	0.895	0.883	0.872	0.861
0.2	1	0.981	0.962	0.944	0.927	0.911	0.895	0.879	0.864	0.850	0.836	0.823
0.25	1	0.976	0.953	0.932	0.911	0.891	0.872	0.854	0.836	0.819	0.803	0.788
0.3	1	0.971	0.944	0.919	0.895	0.872	0.850	0.829	0.810	0.791	0.773	0.756
0.35	1	0.967	0.936	0.907	0.879	0.854	0.829	0.806	0.785	0.764	0.745	0.726
0.4	1	0.962	0.927	0.895	0.864	0.836	0.810	0.785	0.761	0.739	0.718	0.699
0.45	1	0.958	0.919	0.883	0.850	0.819	0.791	0.764	0.739	0.716	0.694	0.673
0.5	1	0.953	0.911	0.872	0.836	0.803	0.773	0.745	0.718	0.694	0.671	0.650
0.55	1	0.949	0.903	0.861	0.823	0.788	0.756	0.726	0.699	0.673	0.650	0.628
0.6	1	0.944	0.895	0.850	0.810	0.773	0.739	0.708	0.680	0.654	0.630	0.607
0.65	1	0.940	0.887	0.840	0.797	0.758	0.723	0.692	0.662	0.636	0.611	0.588
0.7	1	0.936	0.879	0.829	0.785	0.745	0.708	0.676	0.646	0.618	0.593	0.570
0.75	1	0.932	0.872	0.819	0.773	0.731	0.694	0.660	0.630	0.602	0.576	0.553
0.8	1	0.927	0.864	0.810	0.761	0.718	0.680	0.646	0.615	0.586	0.561	0.537
0.85	1	0.923	0.857	0.800	0.750	0.706	0.667	0.632	0.600	0.572	0.546	0.522
0.9	1	0.919	0.850	0.791	0.739	0.694	0.654	0.618	0.586	0.557	0.531	0.508
0.95	1	0.915	0.843	0.782	0.729	0.682	0.642	0.605	0.573	0.544	0.518	0.494
1	1	0.911	0.836	0.773	0.718	0.671	0.630	0.593	0.561	0.531	0.505	0.481

Table 4 - Maximum Nominal Catch Where Actual Catch < ACE With a Probability of 84 pct

	CV											
Discards as Pct of Catch	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
0	1	1	1	1	1	1	1	1	1	1	1	1
0.05	1	0.998	0.995	0.993	0.990	0.988	0.985	0.983	0.980	0.978	0.976	0.973
0.1	1	0.995	0.990	0.985	0.980	0.976	0.971	0.966	0.962	0.957	0.952	0.948
0.15	1	0.993	0.985	0.978	0.971	0.964	0.957	0.950	0.943	0.937	0.930	0.924
0.2	1	0.990	0.980	0.971	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901
0.25	1	0.988	0.976	0.964	0.952	0.941	0.930	0.920	0.909	0.899	0.889	0.879
0.3	1	0.985	0.971	0.957	0.943	0.930	0.917	0.905	0.893	0.881	0.870	0.858
0.35	1	0.983	0.966	0.950	0.935	0.920	0.905	0.891	0.877	0.864	0.851	0.839
0.4	1	0.980	0.962	0.943	0.926	0.909	0.893	0.877	0.862	0.847	0.833	0.820
0.45	1	0.978	0.957	0.937	0.917	0.899	0.881	0.864	0.847	0.832	0.816	0.802
0.5	1	0.976	0.952	0.930	0.909	0.889	0.870	0.851	0.833	0.816	0.800	0.784
0.55	1	0.973	0.948	0.924	0.901	0.879	0.858	0.839	0.820	0.802	0.784	0.768
0.6	1	0.971	0.943	0.917	0.893	0.870	0.847	0.826	0.806	0.787	0.769	0.752
0.65	1	0.969	0.939	0.911	0.885	0.860	0.837	0.815	0.794	0.774	0.755	0.737
0.7	1	0.966	0.935	0.905	0.877	0.851	0.826	0.803	0.781	0.760	0.741	0.722
0.75	1	0.964	0.930	0.899	0.870	0.842	0.816	0.792	0.769	0.748	0.727	0.708
0.8	1	0.962	0.926	0.893	0.862	0.833	0.806	0.781	0.758	0.735	0.714	0.694
0.85	1	0.959	0.922	0.887	0.855	0.825	0.797	0.771	0.746	0.723	0.702	0.681
0.9	1	0.957	0.917	0.881	0.847	0.816	0.787	0.760	0.735	0.712	0.690	0.669
0.95	1	0.955	0.913	0.875	0.840	0.808	0.778	0.750	0.725	0.701	0.678	0.657
1	1	0.952	0.909	0.870	0.833	0.800	0.769	0.741	0.714	0.690	0.667	0.645

Table 5 – Discards plus 1.96 times SE as a percent of nominal catch; bias multiplier of 2 (nominal discards are half true discards)

	CV											
Nominal discards as a Pct of Catch	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
0	0	0	0	0	0	0	0	0	0	0	0	0
0.05	0.100	0.110	0.120	0.129	0.139	0.149	0.159	0.169	0.178	0.188	0.198	0.208
0.1	0.200	0.220	0.239	0.259	0.278	0.298	0.318	0.337	0.357	0.376	0.396	0.416
0.15	0.300	0.329	0.359	0.388	0.418	0.447	0.476	0.506	0.535	0.565	0.594	0.623
0.2	0.400	0.439	0.478	0.518	0.557	0.596	0.635	0.674	0.714	0.753	0.792	0.831
0.25	0.500	0.549	0.598	0.647	0.696	0.745	0.794	0.843	0.892	0.941	0.990	1.039
0.3	0.600	0.659	0.718	0.776	0.835	0.894	0.953	1.012	1.070	1.129	1.188	1.247
0.35	0.700	0.769	0.837	0.906	0.974	1.043	1.112	1.180	1.249	1.317	1.386	1.455
0.4	0.800	0.878	0.957	1.035	1.114	1.192	1.270	1.349	1.427	1.506	1.584	1.662
0.45	0.900	0.988	1.076	1.165	1.253	1.341	1.429	1.517	1.606	1.694	1.782	1.870
0.5	1.000	1.098	1.196	1.294	1.392	1.490	1.588	1.686	1.784	1.882	1.980	2.078
0.55	1.100	1.208	1.316	1.423	1.531	1.639	1.747	1.855	1.962	2.070	2.178	2.286
0.6	1.200	1.318	1.435	1.553	1.670	1.788	1.906	2.023	2.141	2.258	2.376	2.494
0.65	1.300	1.427	1.555	1.682	1.810	1.937	2.064	2.192	2.319	2.447	2.574	2.701
0.7	1.400	1.537	1.674	1.812	1.949	2.086	2.223	2.360	2.498	2.635	2.772	2.909
0.75	1.500	1.647	1.794	1.941	2.088	2.235	2.382	2.529	2.676	2.823	2.970	3.117
0.8	1.600	1.757	1.914	2.070	2.227	2.384	2.541	2.698	2.854	3.011	3.168	3.325
0.85	1.700	1.867	2.033	2.200	2.366	2.533	2.700	2.866	3.033	3.199	3.366	3.533
0.9	1.800	1.976	2.153	2.329	2.506	2.682	2.858	3.035	3.211	3.388	3.564	3.740
0.95	1.900	2.086	2.272	2.459	2.645	2.831	3.017	3.203	3.390	3.576	3.762	3.948
1	2.000	2.196	2.392	2.588	2.784	2.980	3.176	3.372	3.568	3.764	3.960	4.156

Table 6 – Landings plus discards plus 1.96 times SE of discards, as a percent of nominal catch; bias multiplier of 2

	CV											
Landings as Pct of Nominal Catch	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
1	1	1	1	1	1	1	1	1	1	1	1	1
0.95	1.050	1.060	1.070	1.079	1.089	1.099	1.109	1.119	1.128	1.138	1.148	1.158
0.9	1.100	1.120	1.139	1.159	1.178	1.198	1.218	1.237	1.257	1.276	1.296	1.316
0.85	1.150	1.179	1.209	1.238	1.268	1.297	1.326	1.356	1.385	1.415	1.444	1.473
0.8	1.200	1.239	1.278	1.318	1.357	1.396	1.435	1.474	1.514	1.553	1.592	1.631
0.75	1.250	1.299	1.348	1.397	1.446	1.495	1.544	1.593	1.642	1.691	1.740	1.789
0.7	1.300	1.359	1.418	1.476	1.535	1.594	1.653	1.712	1.770	1.829	1.888	1.947
0.65	1.350	1.419	1.487	1.556	1.624	1.693	1.762	1.830	1.899	1.967	2.036	2.105
0.6	1.400	1.478	1.557	1.635	1.714	1.792	1.870	1.949	2.027	2.106	2.184	2.262
0.55	1.450	1.538	1.626	1.715	1.803	1.891	1.979	2.067	2.156	2.244	2.332	2.420
0.5	1.500	1.598	1.696	1.794	1.892	1.990	2.088	2.186	2.284	2.382	2.480	2.578
0.45	1.550	1.658	1.766	1.873	1.981	2.089	2.197	2.305	2.412	2.520	2.628	2.736
0.4	1.600	1.718	1.835	1.953	2.070	2.188	2.306	2.423	2.541	2.658	2.776	2.894
0.35	1.650	1.777	1.905	2.032	2.160	2.287	2.414	2.542	2.669	2.797	2.924	3.051
0.3	1.700	1.837	1.974	2.112	2.249	2.386	2.523	2.660	2.798	2.935	3.072	3.209
0.25	1.750	1.897	2.044	2.191	2.338	2.485	2.632	2.779	2.926	3.073	3.220	3.367
0.2	1.800	1.957	2.114	2.270	2.427	2.584	2.741	2.898	3.054	3.211	3.368	3.525
0.15	1.850	2.017	2.183	2.350	2.516	2.683	2.850	3.016	3.183	3.349	3.516	3.683
0.1	1.900	2.076	2.253	2.429	2.606	2.782	2.958	3.135	3.311	3.488	3.664	3.840
0.05	1.950	2.136	2.322	2.509	2.695	2.881	3.067	3.253	3.440	3.626	3.812	3.998
0	2.000	2.196	2.392	2.588	2.784	2.980	3.176	3.372	3.568	3.764	3.960	4.156
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 7 - Maximum Nominal Catch As A Percent of ACE Such That Actual Catch < ACE With a Probability of 97.5 pct; bias multiplier of 2

	CV											
Nominal Discards as Pct of Catch	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.05	0.952	0.944	0.935	0.926	0.918	0.910	0.902	0.894	0.886	0.879	0.871	0.864
0.1	0.909	0.893	0.878	0.863	0.849	0.835	0.821	0.808	0.796	0.783	0.772	0.760
0.15	0.870	0.848	0.827	0.808	0.789	0.771	0.754	0.738	0.722	0.707	0.693	0.679
0.2	0.833	0.807	0.782	0.759	0.737	0.716	0.697	0.678	0.661	0.644	0.628	0.613
0.25	0.800	0.770	0.742	0.716	0.692	0.669	0.648	0.628	0.609	0.591	0.575	0.559
0.3	0.769	0.736	0.705	0.677	0.651	0.627	0.605	0.584	0.565	0.547	0.530	0.514
0.35	0.741	0.705	0.672	0.643	0.616	0.591	0.568	0.546	0.527	0.508	0.491	0.475
0.4	0.714	0.676	0.642	0.612	0.584	0.558	0.535	0.513	0.493	0.475	0.458	0.442
0.45	0.690	0.650	0.615	0.583	0.555	0.529	0.505	0.484	0.464	0.446	0.429	0.413
0.5	0.667	0.626	0.590	0.557	0.529	0.503	0.479	0.457	0.438	0.420	0.403	0.388
0.55	0.645	0.603	0.566	0.534	0.505	0.479	0.455	0.434	0.415	0.397	0.381	0.366
0.6	0.625	0.582	0.545	0.512	0.483	0.457	0.434	0.413	0.394	0.376	0.360	0.346
0.65	0.606	0.563	0.525	0.492	0.463	0.437	0.414	0.393	0.375	0.358	0.342	0.328
0.7	0.588	0.544	0.506	0.474	0.445	0.419	0.396	0.376	0.357	0.341	0.326	0.312
0.75	0.571	0.527	0.489	0.456	0.428	0.402	0.380	0.360	0.342	0.325	0.311	0.297
0.8	0.556	0.511	0.473	0.440	0.412	0.387	0.365	0.345	0.327	0.311	0.297	0.284
0.85	0.541	0.496	0.458	0.426	0.397	0.373	0.351	0.332	0.314	0.299	0.284	0.272
0.9	0.526	0.482	0.444	0.412	0.384	0.359	0.338	0.319	0.302	0.287	0.273	0.260
0.95	0.513	0.468	0.431	0.399	0.371	0.347	0.326	0.307	0.291	0.276	0.262	0.250
1	0.500	0.455	0.418	0.386	0.359	0.336	0.315	0.297	0.280	0.266	0.253	0.241

Figure 1 – Effects of discard bias on maximum catch (as a percent of ACE) such that there is a high probability that true catch does not exceed allocated ACE. Nominal discards are assumed to be 10 percent of nominal catch. Lines indicate the maximum percent of ACE that can be caught (nominal landings plus discards) with a high probability that the allocated ACE is not exceeded.

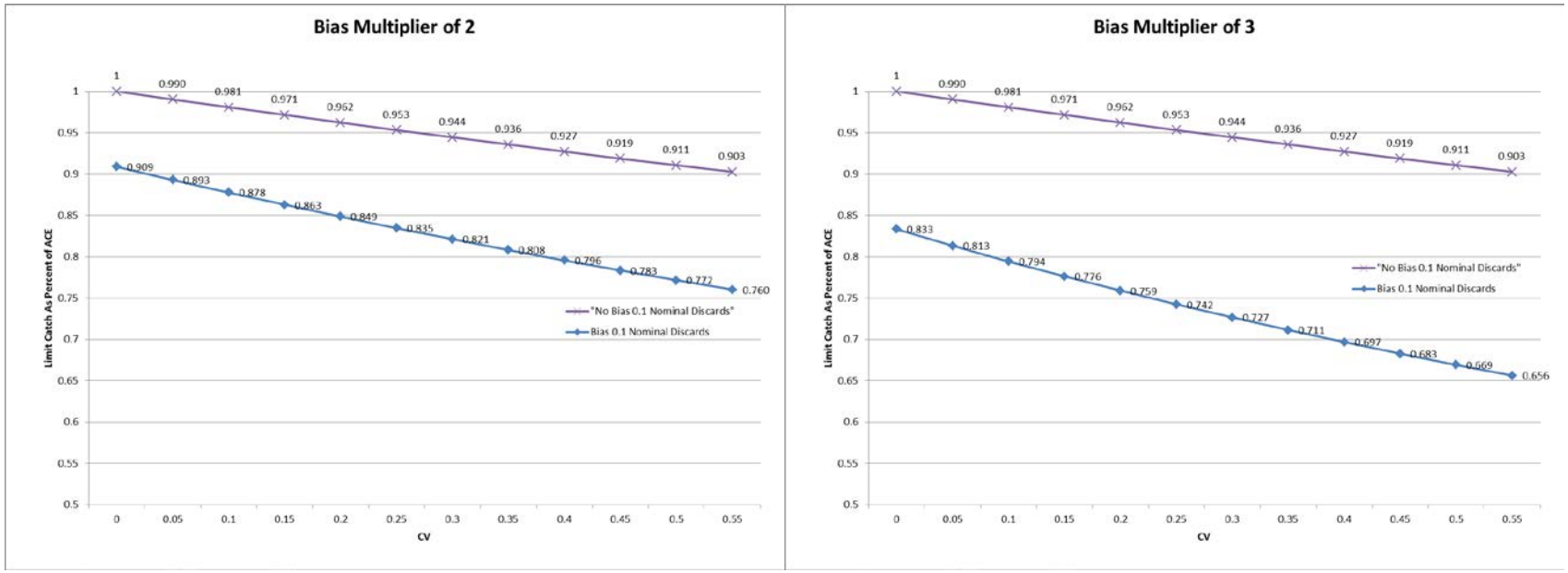

Figure 2 - Effects of discard bias on maximum catch (as a percent of ACE) such that there is a high probability that true catch does not exceed allocated ACE. Bias multiplier of 2, nominal discards are assumed to be a percent of nominal catch as shown. Lines indicate the maximum percent of ACE that can be caught (nominal landings plus discards) with a high probability that the allocated ACE is not exceeded.

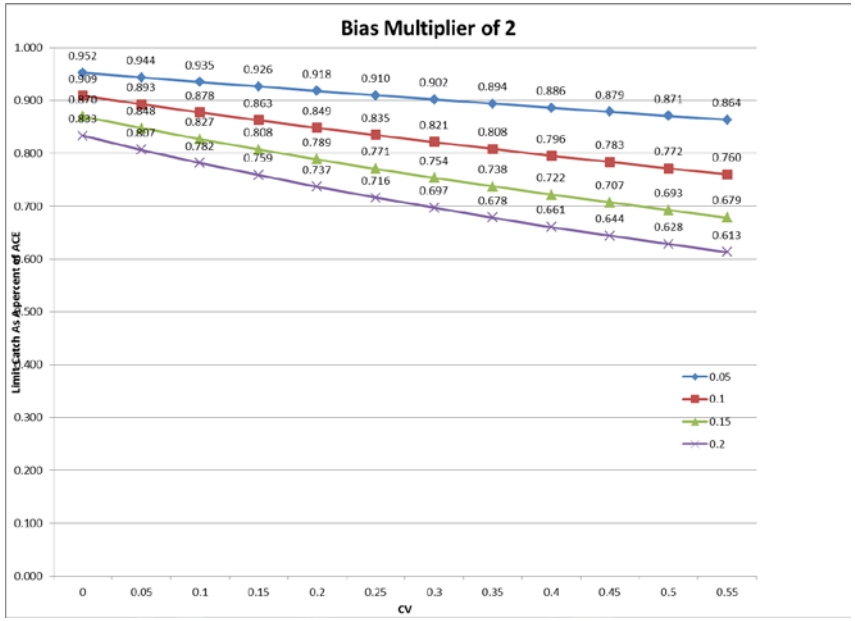

Figure 3 – Relative difference between discard ratio on observed and unobserved trips at different levels of observed kept catch.